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From the INTERNATIONAL BUREAU

NOTICE INFORMING THE APPLICANT OF THE
COMMUNICATION OF THE INTERNATIONAL
APPLICATION TO THE DESIGNATED OFFICES

(PCT Rule 47.1(c), first sentence)

To:

HYDEN, Martin
ETUDES ET PRODUCTIONS SCHLUMBERGER
PROPRIETE INTELLECTUELLE
1, rue Henri Becquerel, BP 202
F-92142 CLAMART Cedex
FRANCE

MK 5/11/0)

Date of mailing *(day/month/year)* 23 October 2003 (23.10.03)	
Applicant's or agent's file reference 21.1035	**IMPORTANT NOTICE**

International application No. PCT/EP03/50100	International filing date *(day/month/year)* 10 April 2003 (10.04.03)	Priority date *(day/month/year)* 17 April 2002 (17.04.02)

Applicant SERVICES PETROLIERS SCHLUMBERGER, et al	*HT*

1. Notice is hereby given that the International Bureau has communicated, as provided in Article 20, the international application to the following designated Offices on the date indicated above as the date of mailing of this notice:

   AU, AZ, BY, CH, CN, CO, DE, DZ, HU, JP, KG, KP, KR, MD, MK, MZ, RU, TM, US

   In accordance with Rule 47.1(c), third sentence, those Offices will accept the present notice as conclusive evidence that the communication of the international application has duly taken place on the date of mailing indicated above and no copy of the international application is required to be furnished by the applicant to the designated Office(s).

2. The following designated Offices have waived the requirement for such a communication at this time:

   AE, AG, AL, AM, AP, AT, BA, BB, BG, BR, BZ, CA, CR, CU, CZ, DK, DM, EA, EC, EE, EP, ES, FI, GB, GD, GE, GH, GM, HR, ID, IL, IN, IS, KE, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MG, MN, MW, MX, NO, NZ, OA, OM, PH, PL, PT, RO, SC, SD, SE, SG, SK, SL, TJ, TN, TR, TT, TZ, UA, UG, UZ, VC, VN, YU, ZA, ZM, ZW

   The communication will be made to those Offices only upon their request. Furthermore, those Offices do not require the applicant to furnish a copy of the international application (Rule 49.1(a-*bis*)).

3. Enclosed with this notice is a copy of the international application as published by the International Bureau on 23 October 2003 (23.10.03) under No. 03/087882

4. **TIME LIMITS for filing a demand for international preliminary examination and for entry into the national phase**

   The applicable time limit for entering the national phase will, subject to what is said in the following paragraph, be 30 MONTHS from the priority date, not only in respect of any elected Office if a demand for international preliminary examination is filed before the expiration of 19 months from the priority date, but also in respect of any designated Office, in the absence of filing of such demand, where Article 22(1) as modified with effect from 1 April 2002 applies in respect of that designated Office. For further details, see *PCT Gazette* No. 44/2001 of 1 November 2001, pages 19926, 19932 and 19934, as well as the *PCT Newsletter*, October and November 2001 and February 2002 issues.

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   For filing a demand for international preliminary examination, see the *PCT Applicant's Guide*, Volume I/A, Chapter IX. Only an applicant who is a national or resident of a PCT Contracting State which is bound by Chapter II has the right to file a demand for international preliminary examination (at present, all PCT Contracting States are bound by Chapter II).

   It is the applicant's sole responsibility to monitor all these time limits.

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Facsimile No.(41-22) 740.14.35	Telephone No.(41-22) 338.91.11

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(71) Applicant *(for FR only)*: SERVICES PETROLIERS SCHLUMBERGER [FR/FR]; 42 rue Saint-Dominique, 42 rue Saint Dominique, F-75007 Paris (FR).

(71) Applicant *(for JP, NL only)*: SCHLUMBERGER HOLDINGS LIMITED [—/—]; PO BOX 71, Craingmuir Chambers Road Town, PO BOX 71, Craingmuir Chambers, Road Town (VG).

(71) Applicant *(for CA, GB only)*: SCHLUMBERGER CANADA LIMITED [CA/CA]; 24th- Floor - Monenco Place, 801 6th Avenue SW. 24th- Floor - Monenco Place, 801 6th Avenue SW, Calgary, Alberta T2P 3W2 (CA).

(71) Applicant *(for BF, BJ, CF, CG, CI, CM, CZ, GA, GN, GQ, GW, IN, LT, MA, ML, MR, NE, SN, TD, TG, TN, VN only)*: PETROLEUM RESEARCH & DEVELOPMENT N.V. [NL/NL]; De Ruyterkade 26, Willemstad, Curacao (AN).

(71) Applicant *(for AE, AG, AL, AM, AT, AU, AZ, BA, BB, BE, BG, BR, BY, BZ, CH, CN, CO, CR, CU, CY, CZ, DE, DK, DM, DZ, EC, EE, ES, FI, GD, GE, GH, GM, GR, HR, HU, ID, IE, IL, IS, IT, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LU, LV, MC, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, PH, PL, PT, RO, RU, SC, SD, SE, SG, SI, SK, SL, SZ, TJ, TM, TZ, UA, UG, UZ, VC, VN, YU, ZA, ZM, ZW only)*: SCHLUMBERGER TECHNOLOGY B.V. [NL/NL]; Parkstraat 83-89, NL-2514 JG The Hague (NL).

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(54) Title: PROCESS FOR DETERMINING THE RESISTIVITY OF A FORMATION THROUGH WHICH A WELL EQUIPPED WITH A CASING PASSES
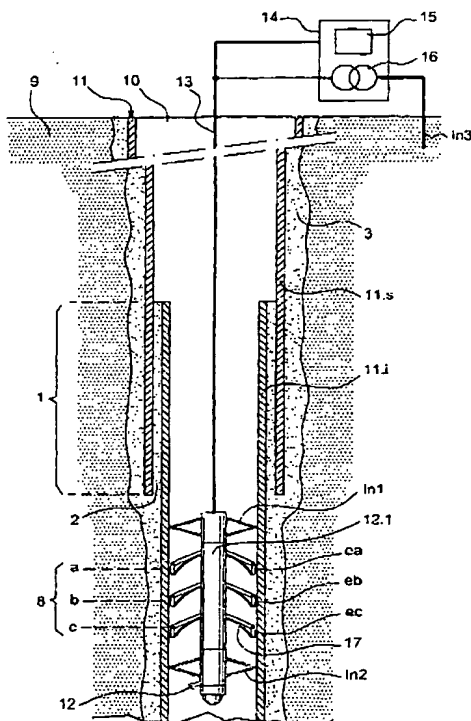
(57) Abstract: Process for determining the resistivity (Rt) of a formation (9) surrounding a well (10) equipped with a casing (11) consisting of several casing segments (11.i, 11.s) with an overlapping part (1), and cement (3) in the overlapping part (1), in which a current is injected into the casing (11) to cause a leakage current (I for) into a area (8) of the formation (9) offset from the overlapping part (1), the leakage current (Ifor) in the measurement area (8) is determined and is used to deduce the measured resistivity (Rm) of the formation, a current is injected into the casing (11) to cause a current leakage (Icem) in the cement (3) of the overlapping part (1), the leakage current (Icem) in the cement (3) in the overlapping part (1) is determined, and is used to deduce the measured resistivity (Rcem) of the cement (3), the measured resistivity (Rm) of the formation (9) is corrected using a factor to take account of the measured resistivity (Rcem) of the cement (3) to obtain the resistivity (Rt) of the formation (9). Application particularly to oil exploration.

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PROCESS FOR DETERMINING THE RESISTIVITY OF A FORMATION THROUGH WHICH A WELL EQUIPPED WITH A CASING PASSES

DESCRIPTION

Technical field

This invention relates to a process for determining the resistivity of a geological formation through which a well equipped with an electrically conducting casing passes .

The importance of resistivity diagraphs for oil exploration is now universally accepted. It is known that the resistivity of a geological formation depends essentially on the fluid contained in it. This type of resistivity measurement is frequently made on formations passed through to decide whether or not to put an oil well into operation, so that its saturation in fluid (mainly brine or fresh water, or hydrocarbons including crude oil and gas, or a mixture of one or several of these fluids). A formation containing brine has a much lower resistivity than a formation containing hydrocarbons.

State of prior art

Measurements using prior art are made using systems provided with electrodes to measure currents or voltages.

Resistivity diagraphs in open holes have been made for several decades.

We are now beginning to make resistivity measurements in wells reaching hydrocarbon reservoirs

in operation and these wells are equipped with a casing. These measurements are used to determine the location of water-hydrocarbon interfaces and to monitor the change in level of these interfaces with time in

5   order to monitor the behavior of the hydrocarbon reservoir and optimize its operation.

Resistivity measurements can also be made in wells in which no measurements were made before the casing was installed, particularly to increase knowledge about

10   the hydrocarbon reservoir, and possibly to detect production layers that were not identified initially.

These resistivity measurements in wells equipped with a casing are not easy to make since the resistivity of the casing (of the order of 2 x 10^{-7} Ω.m

15   for a steel casing) is very small compared with the resistivity of the formation (between about 1 and 10^3 Ω.m) and the casing forms a barrier to the transfer of current into the formation around the well beyond the casing.

20   The measurement principle consists of circulating an electric current along the casing under conditions such that a leak or current loss occurs towards the formation. This leak depends on the resistivity of the formation, and is greater when the formation has a high

25   conductivity. It can be evaluated by making measurements of the voltage drop between electrodes placed at different levels in the well. These voltage drops are of the order of a few nanovolts.

This type of measurement principle is described in

30   a large number of patents and particularly in French

patent applications FR-A1-2 793 031 and FR-A1-2 793 032 issued by the applicant.

Refer to figure 1 that shows a section of a well 10 with centerline XX', equipped with a metallic casing 11, in a formation 9. The level at which the measurement will be made is marked b. We consider a section a-c of casing 11 extending on each side of level b. A current is circulated in the casing 11 with a return remote from level b, for example at the surface. There is a current leakage Ifor in formation 9 and in terms of the electrical circuit, this current leakage is equivalent to the current passing through a shunt resistance Rt located between level b and infinity. The value of this shunt resistance Rt is representative of the resistivity (also called Rt) of the formation at level b. Thus according to Ohm's law, we can write :

$$Rt = K \ (V_b, \infty \ / \ Ifor)$$

K is a geometric constant that may be determined particularly by calibration, by moving into an impermeable area of the formation 9 in which the resistivity is already known through measurements made in the open hole before the well is put into operation.

V_b, ∞ is the potential at level b with reference to a point at infinity. It is measured using a measurement electrode eb placed at level b in electrical contact with the inside of casing 11 and a reference electrode (not shown) that may be placed on the surface.

Ifor is the leakage current in the formation 9 at level b, and may for example be determined using the

This method comprises three steps. In a first step, a current is injected into the casing 11 at a point In1 at a longitudinal distance along the formation 9 so as to cause a current leakage, and

5   electrodes ea, eb and ec placed at levels a, b and c respectively are used to measure the potential drops along casing sections a-b and b-c respectively. In a second step, a current is injected into the casing 11 at point In2 at a longitudinal distance along the

10   formation 9 located on the side opposite the first point In1 to create a current leakage in the formation 9. Electrodes ea, eb and ec are used to measure the potential drops along casing sections a-b and b-c respectively. In a third step, the corresponding

15   measurements in the previous two steps are combined in order to obtain voltage values corresponding to a circuit formed by the casing between the two injection points In1, In2 without any current leakage to the formation. The leakage current Ifor in the formation 9

20   is determined from the first step or the second step, with the values resulting from the combination.

There is another non-negligible barrier to sending current in the formation. This is the cement 3 that is poured into the well 10 to hold the casing 11 in

30   position. It fills in the inevitable space between the

equivalent to the resistance in series with the shunt resistance Rt due to the formation 9.

The resistivity of cement can be known by laboratory measurements. The resistivity of fresh cement is typically within a range between 1 and 10 Ω.m. Once in place, the cement 3 is no longer directly accessible since it is behind the casing 11.

Furthermore, its resistivity varies firstly with time and secondly with the medium in which it is located. Resistivity measurements in the well equipped with a casing 10 may be made over several years or decades after the cement has been placed, and it is not known what has happened to the cement during this time.

The porosity of the cement is of the order of 35% and when it is in place, there is an ion exchange between the water contained in the cement and the water contained in the formation.

French patent FR-A1-2 807 167 application issued by the applicant disclosed a process to determine the resistivity of a formation through which the well equipped with a casing passes, taking account of the effect of the cement. The authors found that the measured value of the resistivity of the formation could be corrected taking account of the thickness of the cement and its resistivity to obtain the "genuine" resistivity. "Genuine" resistivity means a value of the resistivity that is as close as possible to the real value of the resistivity that is unknown and that is required.

Correction nomograms are used to find a correction

equal to the ratio between the required resistivity and the resistivity measured for the formation at the measurement area, and this factor takes account of the ratio between the measured resistivity of the formation

5 and the resistivity of cement.

These nomograms are produced from mathematical models.

The thickness of the cement layer may be evaluated with acceptable precision if the outside diameter of

10 the casing 11 and the inside diameter of the well 10 before casing are known.

The resistivity of the cement is not known, and the estimate used to make it is far from reality. The use of nomograms is not particularly efficient for

15 correcting the value of the measured resistivity of the formation to obtain the value of the resistivity of the formation. The result is an approximate value with mediocre precision.

20 Description of the invention

This invention is intended to improve the precision of the correction by proposing a method to give a more precise value of the resistivity of the formation using nomograms, a value of the measured

25 resistivity of the formation and a value of the resistivity of the cement obtained from measurements.

In order to achieve this, this invention consists of a process for determining the resistivity of a geological formation surrounding a well equipped with a

30 casing consisting of several casing segments following

have an overlapping part, and the cement located between the casing and the formation and in the overlapping part between two adjacent casing segments,

in which a current is injected into the casing to
5   cause a leakage current into an area of the formation for which measurements are required, offset from the overlapping part, the leakage current in the measurement area is determined and is used to deduce the measured resistivity of the formation in the
10   measurement area,

a current is injected into the casing to cause a current leakage in the cement of the overlapping part, the leakage current in the cement in the overlapping part is determined and is used to deduce the measured
15   resistivity of the cement,

the measured resistivity of the formation is corrected using a factor to take account of the measured resistivity of the cement to obtain the resistivity of the formation.

20   The correction factor is equal to the ratio between the resistivity and the measured resistivity of the formation as a function of the ratio between the measured resistivity of the formation and the measured resistivity of the cement, for a given cement thickness
25   within the area being measured in the formation.

The correction factor may be given in nomograms starting from the measured resistivity of the formation and the measured resistivity of cement.

The measured resistivity of the formation can be
30   deduced from the leakage current in the measurement

area and the casing potential in the measurement area
with respect to a reference at infinity.

The measured resistivity of the cement can be
deduced from the leakage current in the cement in the
5   overlapping part and the casing potential in the
overlapping part with respect to a reference at
infinity.

The current injected into the casing to cause the
leakage current in the cement in the overlapping part
10   is such that it does not cause a..y leakage current in
the formation behind the overlapping part.

The leakage current in the measurement area and
the leakage current in the cement may be determined
using a probe provided with measurement electrodes in
15   contact with the casing, this probe being moved in the
well to move to the measurement area and to the level
of the overlapping part, respectively.

Current may be injected into the casing using the
probe that is equipped with at least one current
20   injector.

Brief description of the drawings

This invention will be better understood after
reading the description of example embodiments given
25   for information only and that are in no way
restrictive, with reference to the attached drawings on
which :

Figure 1, already described, shows the resistivity
measurement principle in a well equipped with a
30   casing ;

Figures 2A and 2B diagrammatically show a device for embodiment of the process according to the invention in two different measurement positions ;

5   Figure 3 is an example of correction nomograms used to correct the measured resistivity value of the formation ;

Figures 4A to 4D show simulations of the variation of the leakage current in the formation as a function of the depth, for various values of resistivity of the

10   cement, and for several resistivities of the formation, several diameters of casing segments, and several lengths of the overlapping part.

Identical elements on these figures are marked with the same reference marks.

15

Detailed description of particular embodiments

We will now refer to figures 2A and 2B that show an example of a device for implementation of the process according to the invention, in two different

20   positions. The device may be comparable to the device described in French patent application FR-A1-2 793 031 mentioned above.

The device shown comprises a probe 12 that can be displaced in a well 10 formed in a geological formation

25   9 and equipped with an electric conducting casing 11.

The casing 11 is formed from several casing segments, usually made of steel. Only two of these casing segments have been referenced to avoid making the figures too complicated, one is called the upper

30   segment 11.s and the other is called the lower segment

diameter, and they are coaxial when they are in position. These casing segments are lowered into the well 10 one after the other, from the thinnest to the thickest, and including an overlapping part 1 between

5 two casing segments 11.s and 11.i. The two successive casing segments 11.s, 11.i do not have the same diameter, therefore there is a space 2 between the outside diameter of the lower casing segment 11.i and the inside diameter of the upper casing segment 11.s.

10 The casing 11 is cemented to hold it in position in the well 10. The cement 3 is poured between the outside of the casing segments and the formation in which the well 10 is bored. The cement 3 also enters the space 2.

The probe 12 is connected by an electrical cable

15 13 to equipment 14 located on the surface. This equipment 14 may comprise means of acquisition and processing of data 15 supplied by the probe 12 and electrical power supply means 16.

The probe 12 comprises a body 12.1 and a group of

20 at least three measurement electrodes ea, eb and ec that can come into contact with casing 11 by delimiting casing sections a-b, b-c. For example, the length of these segments may be between 40 and 80 centimeters. Electrodes ea, eb, and ec may be installed at the ends

25 of the articulated arm 17 that connect them to body 12.1. These arms 17 are known in themselves, they are extended to come into contact with electrodes ea, eb and ec in contact with casing 11 when it is required to make measurements, and they are retracted when the

30 measurements are terminated. When they are extended,

electrode fitted on them and the casing 11, and when they are retracted they can move the probe without friction inside the casing 11. The probe 12 also contains two current injectors In1 and In2 on each side

5 of the group of measurement electrodes ea, eb, and ec.

Insulating connectors 18 are placed on each side around the body 12.1 of the probe 12 between the current injectors In1, In2 and the measurement electrodes ea, eb, and ec to electrically isolate the

10 measurement electrodes ea, eb, and ec from the current injectors In1, In2. The space between a current injector In1, In2 and the measurement electrode ea, ec closest to it may be of the same order of magnitude as the space between two successive measurement

15 electrodes.

The current injectors In1, In2 may be made as described in the patent application FR-A1-2 739 031. They are also placed on the articulated arms.

The device also comprises a current return

20 electrode In3, remote from the injectors. It may be located on the surface at the same level as the cased wellhead 10 if the well is sufficiently deep, or it may be on the surface but remote from the cased wellhead. The current injectors In1, In2 and the current return

25 electrode In3 are powered with electricity, and they are connected to the electrical power supply means that comprise the above mentioned electrical power supply source 16 on the surface and, depending on the case, a supplementary source (not shown) located in the probe

30 12 and appropriate switching circuits to change from

On Figure 2A, the probe 12 is in a position in which it can determine the resistivity of the formation that is located in a measurement area 8 at the group of measurement electrodes ea, eb, ec. These measurement

5   electrodes ea, eb, ec are in contact with the lower casing segment 11.i, and they are remote from the overlapping part 1.

In this position of the probe 12, electrical current is circulated in casing 11 using at least one

10   injector In1, In2 and the potentials are measured using measurement electrodes to determine the leakage current Ifor in the formation 9 in the measurement area 8, for example using the process described in the patent application FR-A1-2 739 031. This leakage current Ifor

15   represents the resistivity of the formation in the measurement area. All that is necessary to obtain the measured resistivity Rm of the formation in the measurement area 8 is to determine the casing potential 11 in the measurement area with respect to a reference

20   at infinity. This can be done as described in patent application FR-A1-2 739 031 using electrode eb and a reference electrode (not shown), for example placed on the surface at a distance from the current return electrode In3 or in the well.

25   The probe 12 is moved into a second position, the measurement electrodes ea, eb, ec are then at the overlapping part 1.

In general, the measurement area 8 is located more deeply in the formation than the overlapping part 1.

30   Obviously, it would be possible to do the inverse.

The leakage current Icem in the cement 3 in space 2 is determined by circulating current in the casing 11 using at least one current injector of the probe 12 and measuring the potentials using the measurement
5   electrodes ea, eb and ec, this current representing the resistivity of the cement. As before, the measured resistivity Rcem of the cement 3 can then be obtained by determining the potential of the casing 11 in the overlapping part 1 with respect to a reference at
10   infinity. The measured resistivity of the cement Rcem can then be deduced from this value.

Correction nomograms like those illustrated in Figure 3 and those presented in patent application FR-A1-2 807 167 can then be used, to give a value of the
15   correction factor to be applied to the measured resistivity Rm of the formation to obtain a precise value of the required resistivity Rt. his factor is obtained starting from the cement thickness and the ratio between the measured resistivity Rm of the
20   formation in the measurement area 8 and the measured resistivity of the cement Rcem.

In prior art, the resistivity of the cement was simply estimated and not measured, and there can be a large difference between the two values. Consequently,
25   the correction was no longer valid for obtaining a value of the required resistivity as close as possible to the real value.

The precision of the value of the resistivity of the formation obtained with this type of process is
30   significantly improved.

On Figure 3, the thickness of the cement 3 in the measurement area 8 varies between 0 and 5 inches (about 12 centimeters).

This correction should be made when the ratio
5 between the resistivity of the formation Rt and the resistivity of the cement Rcem is less than 1 or when the cement layer is thick, more than about 1.5 inches (about 3.8 centimeters); in other cases the effect of cement can be neglected.

10 A series of simulations was carried out to demonstrate the influence of the cement on the leakage current in the formation compared with other parameters such as the resistivity of the formation, the diameters of casing segments, the length of the overlapping part.
15 These simulations are illustrated in figures 4A to 4D. These simulations were made on a modeled well very similar to that in figures 2.

These simulations show the variations in the leakage current in the formation as a function of the
20 depth between -8500 feet (about 2592 meters) and -9100 feet (about 2775 meters).

A current of 1 A was injected into the lower casing segment 11.i, and the resistivity of the cement 3 was varied between 0.5 and 20 Ω.m and 20 Ω.m, the
25 current electrode In3 being located at the surface of the wellhead 10.

In figure 4A, the length of the overlapping part is 200 feet (about 61 meters), between depth -8500 feet (about 2592 meters) and -8700 feet (about 2653 meters).
30 The lower casing segment 11.i has an outside diameter

casing segment 11.s has an outside diameter of 7 inches (about 18 centimeters). The resistivity Rt of the formation is considered as being uniform and equal to 1 Ω.m. In the overlapping part 1 in which there is a lot

5   of cement, the current in the formation varies very significantly with the resistivity of the cement. These curves are considered as a reference.

The conditions in figure 4B are the same as in figure 4A except for the resistivity of the formation

10   that was increased from 1 Ω.m to 10 Ω.m. In the overlapping part, the current is almost the same as the current shown in figure 4A, which illustrates the small influence of the resistivity of the formation compared with the resistivity of the cement. Away from the

15   overlapping part, the leakage current in the formation is lower since the resistivity of the formation has increased.

In figure 4C, the conditions are the same as in figure 4A except for the outside diameters of the

20   segments of the casing that have changed from 4.5 to 7 inches, and from 7 inches to 9.625 inches (about 24 centimeters) respectively. The thickness of cement between the two segments of the casing 11.s, 11.i has not changed. The shape of the current curves is

25   approximately the same as in figure 4A but the current amplitudes are slightly smaller. The dimensions of the casing segments have a small influence on the leakage current.

In figure 4D, the conditions are the same as in

30   figure 4A except for the length of the overlapping part

meters) between -8200 feet (about 2500 meters) and -
8700 feet. The leakage current remains globally higher
for shallower depths. It can be deduced that it will
become easier to determine the resistivity of the
5   cement as the length of the overlapping part is
increased. It can be seen that for an overlap of 500
feet, the curves contain a plateau which makes the
measurement almost independent of the depth at which it
was made.

10   These simulations show that the leakage current in
the overlapping part is not very sensitive to the
geometric configuration of the casing, and is much more
sensitive to the resistivity of the cement. However, it
is only very slightly influenced by the resistivity of
15   the formation.

CLAIMS

1. Process for determining the resistivity (Rt) of a geological formation (9) surrounding a well (10) equipped with a casing (11) consisting of several casing segments (11.i, 11.s) following each other, in

5 which two successive casing segments (11.i, 11.s) have an overlapping part (1), the cement (3) located between the casing (11) and the formation (9) and in the overlapping part (1) between two adjacent casing segments (11.i, 11.s),

10 in which a current is injected into the casing (11) to cause a leakage current (Ifor) into an area (8) of the formation (9) for which measurements are required, offset from the overlapping part (1), the leakage current (Ifor) in the measurement area (8) is

15 determined and is used to deduce the measured resistivity (Rm) of the formation in the measurement area (8),

characterized in that a current is injected into the casing (11) to cause a current leakage (Icem) in

20 the cement (3) of the overlapping part (1), the leakage current (Icem) in the cement (3) in the overlapping part (1) is determined, and is used to deduce the measured resistivity (Rcem) of the cement (3),

the measured resistivity (Rm) of the formation is

25 corrected using a factor to take account of the measured resistivity (Rcem) of the cement (3) to obtain the resistivity (Rt) of the formation (9).

2. Process according to claim 1, characterized in that the correction factor for a given cement thickness (3) in the measurement area (8) of the formation (9) is equal to the ratio between the resistivity (Rt) and the measured resistivity (Rm) of the formation (9) as a function of the ratio between the measured resistivity (Rm) of the formation (9) and the measured resistivity (Rcem) of the cement (3).

3. Process according to either of claims 1 or 2, characterized in that the correction factor is given in nomograms starting from the measured resistivity (Rm) of the formation (9) and the measured resistivity (Rcem) of the cement (3).

4. Process according to one of claims 1 to 3, characterized in that the measured resistivity (Rm) of the formation is deduced from the leakage current (Ifor) in the measurement area (8) and the potential of the casing (11) in the measurement area (8) with respect to a reference at infinity.

5. Process according to one of claims 1 to 4, characterized in that the measured resistivity (Rcem) of the cement can be deduced from the leakage current (Icem) in the cement (3) in the overlapping part (1) and the potential in the casing (11) in the overlapping part (1) with respect to a reference at infinity.

6. Process according to one of claims 1 to 5,

casing (11) to cause the leakage current (Icem) in the cement (3) in the overlapping part (1) is such that it does not cause any leakage current in the formation (9) behind the overlapping part (1).

5

7. Process according to one of claims 1 to 6, characterized in that the leakage current in the measurement area (8) and the leakage current in the cement (3) are determined using a probe (12) provided

10 with measurement electrodes in contact with the casing (11), this probe (12) being moved in the well (10) to move to the measurement area (8) and to the level of the overlapping part (1), respectively.

15

8. Process according to claim 7, characterized in that the current is injected into the casing (11) using the probe (12) that is equipped with at least one current injector (In1, In2).
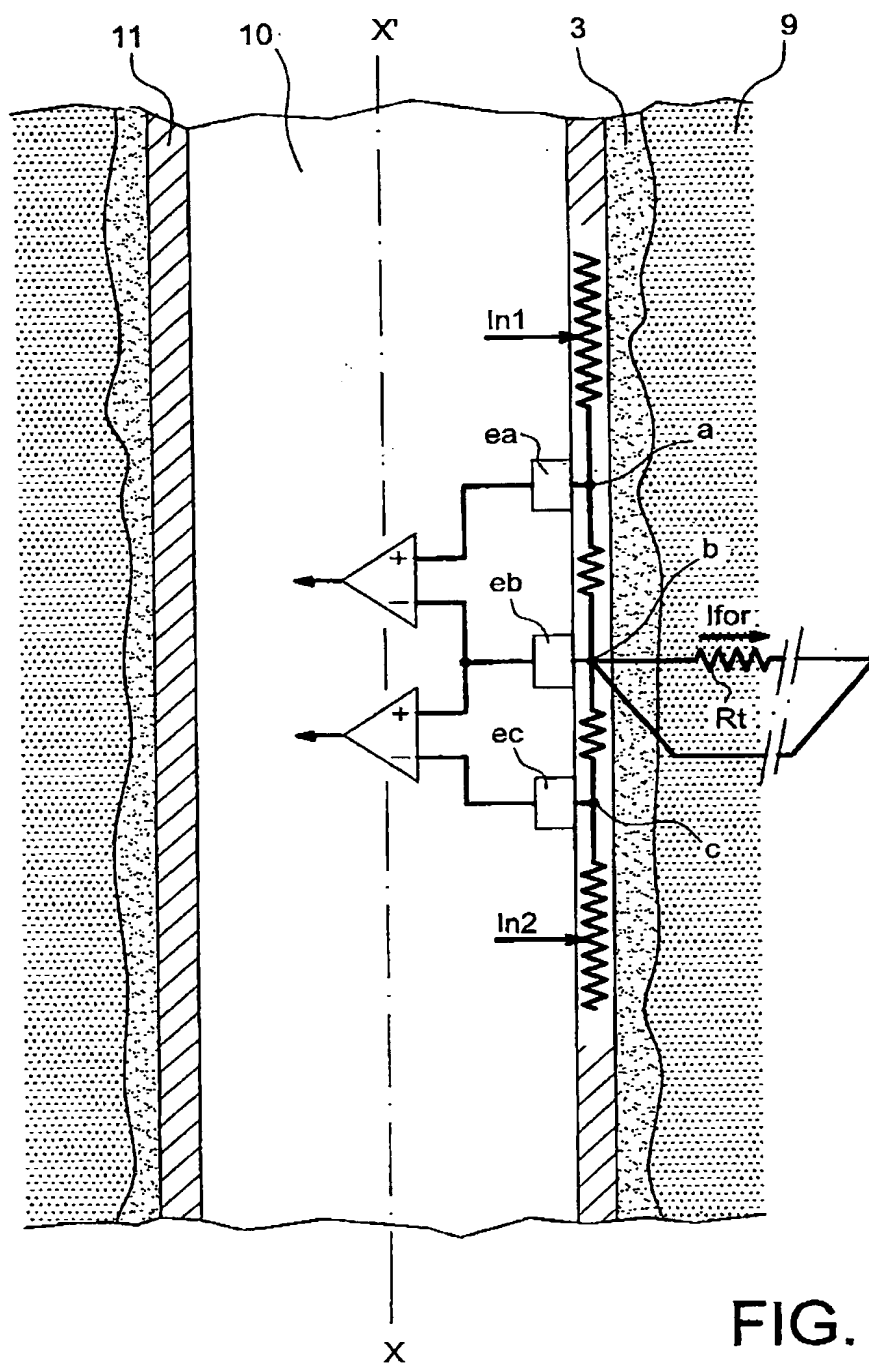
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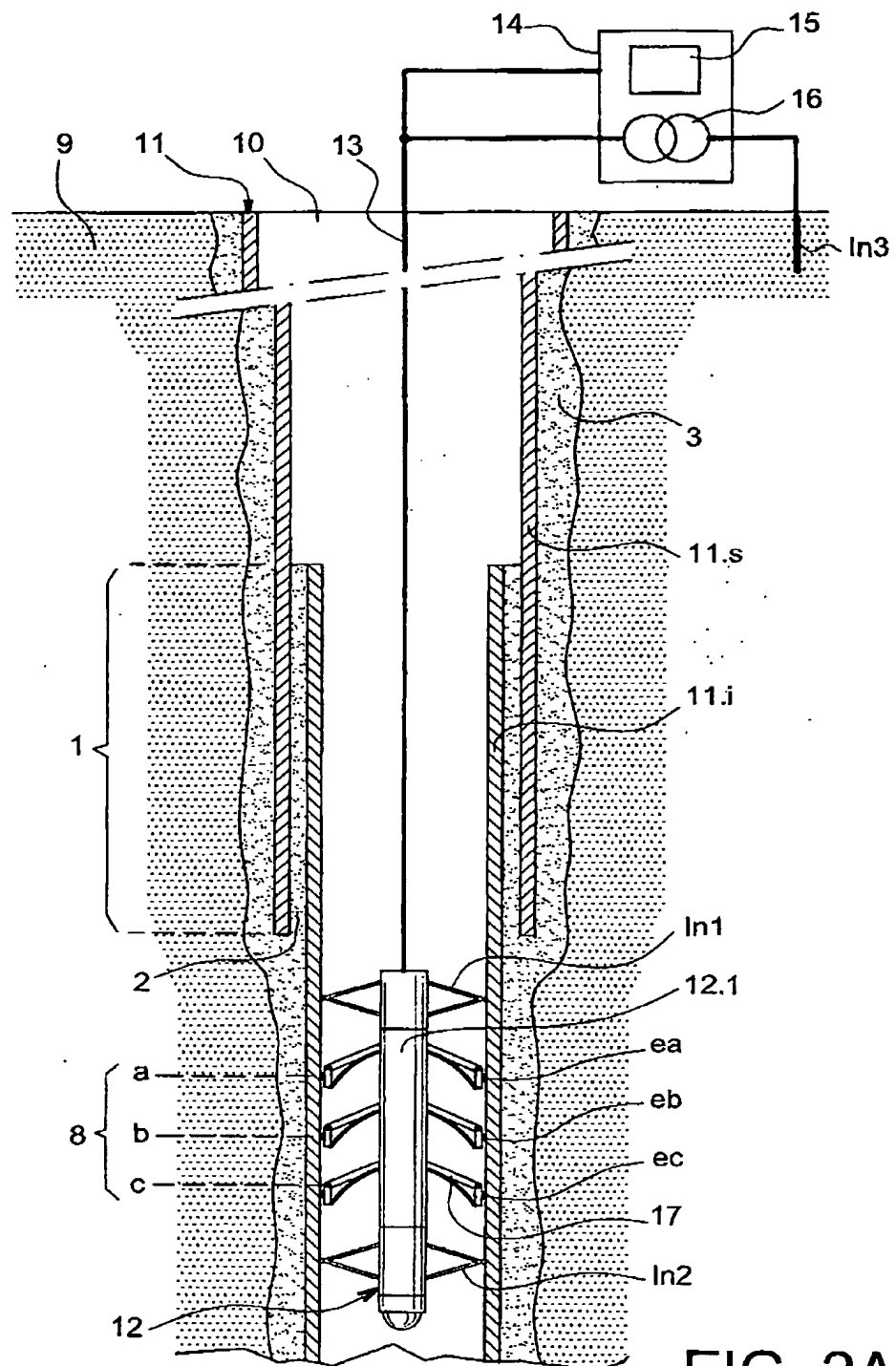
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FIG. 1

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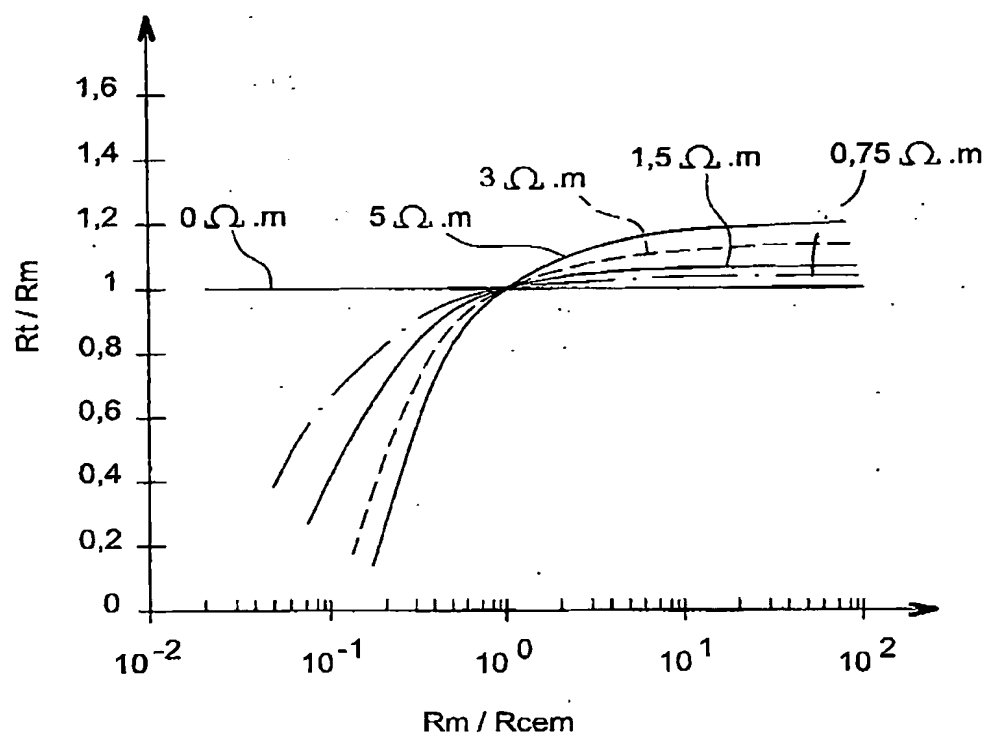
FIG. 2A

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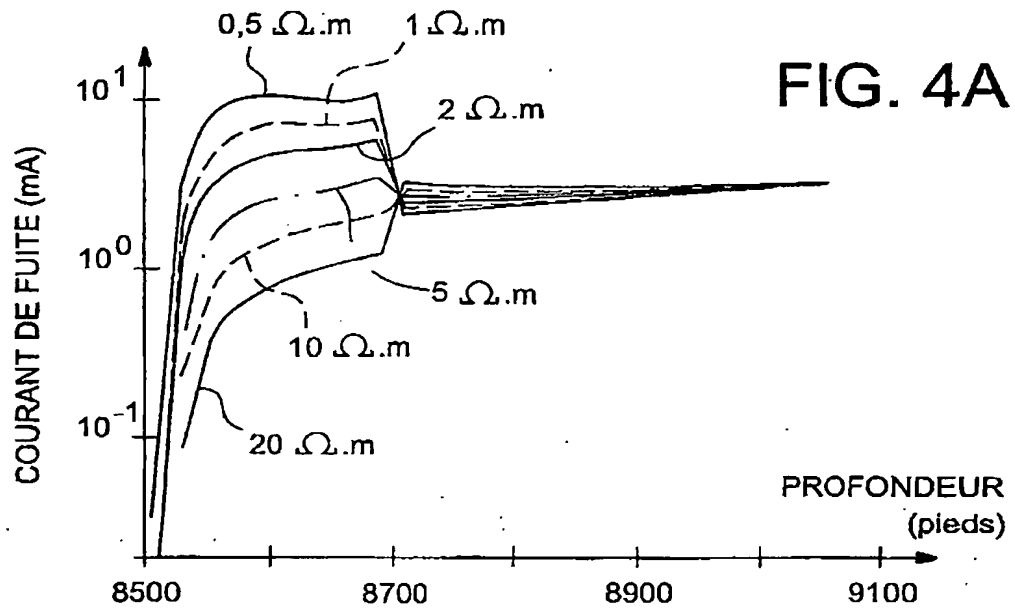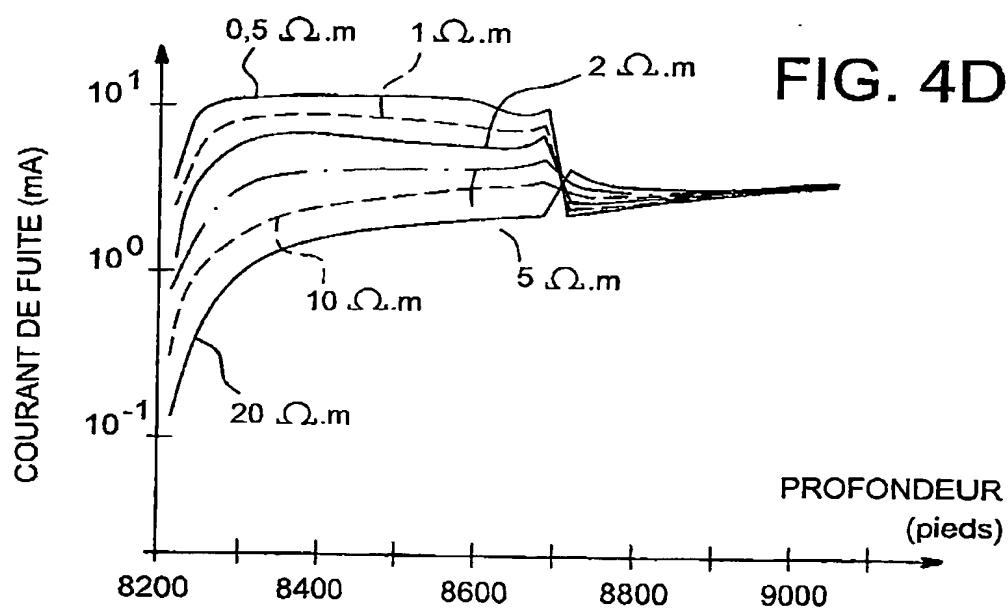
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FIG. 2B

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FIG. 3

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FIG. 4A

FIG. 4B
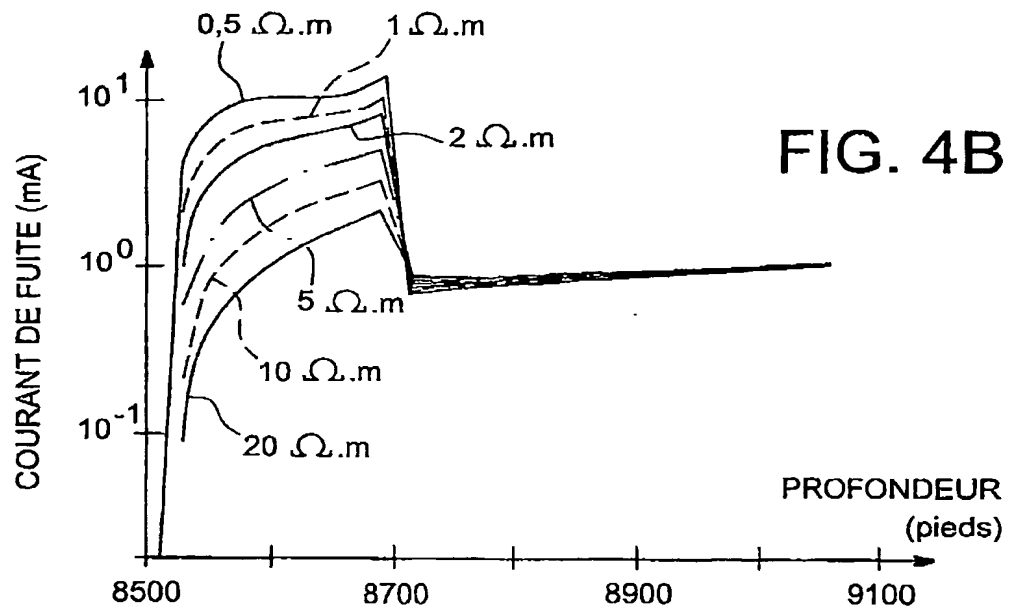
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FIG. 4C

FIG. 4D
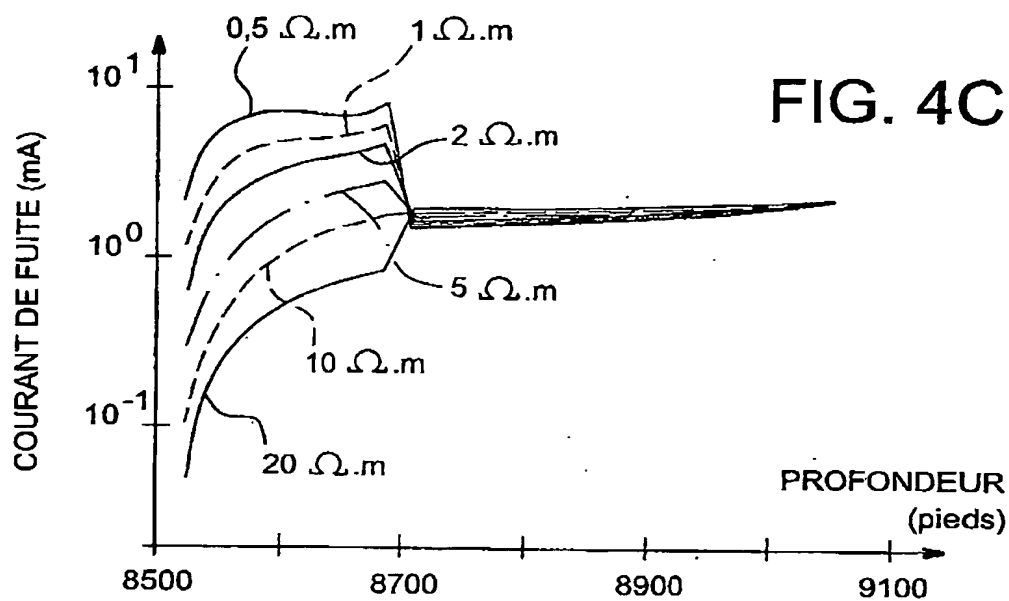
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INTERNATIONAL SEARCH REPORT

A. CLASSIFICATION OF SUBJECT MATTER

IPC 7   G01V3/20

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7   G01V

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, INSPEC

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2001 026156 A1 (FAIVRE OLIVIER ET AL) 4 October 2001 (2001-10-04) page 2, paragraph 16 – paragraph '0021!	1-8
A	FR 2 807 167 A (SCHLUMBERGER SERVICES PETROL) 5 October 2001 (2001-10-05) cited in the application page 5, line 9 – page 6, line 6 page 8, line 23 – line 27 claims	1-4,7,8
A	US 4 820 989 A (VAIL III WILLIAM B) 11 April 1989 (1989-04-11) column 6, line 57 – column 7, line 9	1
	-/—	

[X] Further documents are listed in the continuation of box C.   [X] Patent family members are listed in annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
17 July 2003	28/07/2003

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31–70) 340–2040, Tx. 31 651 epo nl, Fax: (+31–70) 340–3016	Swartjes, H.

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INTERNATIONAL SEARCH REPORT

Internal Application No
PCT/ᴸ, 03/50100

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
A	SCHENKEL C J ET AL: "ELECTRICAL RESISTIVITY MEASUREMENT THROUGH METAL CASING" GEOPHYSICS, SOCIETY OF EXPLORATION GEOPHYSICISTS. TULSA, US, vol. 59, no. 7, 1 July 1994 (1994-07-01), pages 1072-1082, XP000526742 ISSN: 0016-8033	

Interna	I Application No
	PCT/ᴌᵢ 03/50100

Patent document cited in search report		Publication date	Patent family member(s)		Publication date
US 2001026156	A1	04-10-2001	FR GB	2807167 A1 2360849 A ,B	05-10-2001 03-10-2001
FR 2807167	A	05-10-2001	FR GB US	2807167 A1 2360849 A ,B 2001026156 A1	05-10-2001 03-10-2001 04-10-2001
US 4820989	A	11-04-1989	AT CA CA DE EP MX US WO US WO US US US US US US US US US US US	91798 T 1278342 C 2037563 A1 3786671 D1 0329709 A1 161569 A 5570024 A 8803657 A1 4882542 A 9216859 A1 5633590 A 6246240 B1 5075626 A 6249122 B1 5717334 A 6031381 A 6025721 A 5187440 A 5223794 A 2002016675 A1 6157195 A 2002043977 A1	15-08-1993 27-12-1990 06-09-1992 26-08-1993 30-08-1989 06-11-1990 29-10-1996 19-05-1988 21-11-1989 01-10-1992 27-05-1997 12-06-2001 24-12-1991 19-06-2001 10-02-1998 29-02-2000 15-02-2000 16-02-1993 29-06-1993 07-02-2002 05-12-2000 18-04-2002

RAPPORT DE RECHERCHE INTERNATIONALE

A. CLASSEMENT DE L'OBJET DE LA DEMANDE
CIB 7 G01V3/20

Selon la classification internationale des brevets (CIB) ou à la fois selon la classification nationale et la CIB

B. DOMAINES SUR LESQUELS LA RECHERCHE A PORTE
Documentation minimale consultée (système de classification suivi des symboles de classement)
CIB 7 G01V

Documentation consultée autre que la documentation minimale dans la mesure où ces documents relèvent des domaines sur lesquels a porté la recherche

Base de données électronique consultée au cours de la recherche internationale (nom de la base de données, et si réalisable, termes de recherche utilisés)

EPO-Internal, INSPEC

C. DOCUMENTS CONSIDÉRES COMME PERTINENTS

Catégorie *	Identification des documents cités, avec, le cas échéant, l'indication des passages pertinents	no. des revendications visées
A	US 2001 026156 A1 (FAIVRE OLIVIER ET AL) 4 octobre 2001 (2001-10-04) page 2, alinéa 16 - alinéa '0021!	1-8
A	FR 2 807 167 A (SCHLUMBERGER SERVICES PETROL) 5 octobre 2001 (2001-10-05) cité dans la demande page 5, ligne 9 - page 6, ligne 6 page 8, ligne 23 - ligne 27 revendications	1-4,7,8
A	US 4 820 989 A (VAIL III WILLIAM B) 11 avril 1989 (1989-04-11) colonne 6, ligne 57 - colonne 7, ligne 9	1

-/--

[X] Voir la suite du cadre C pour la fin de la liste des documents

[X] Les documents de familles de brevets sont indiqués en annexe

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17 juillet 2003	28/07/2003

Nom et adresse postale de l'administration chargée de la recherche internationale	Fonctionnaire autorisé
Office Européen des Brevets, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax (+31-70) 340-3016	Swartjes, H.

Formulaire PCT/ISA/210 (deuxième feuille) (juillet 1992)

RAPPORT DE RECHERCHE INTERNATIONALE

Demande internationale No
PCT/L, 03/50100

C.(suite) DOCUMENTS CONSIDERES COMME PERTINENTS

Catégorie	Identification des documents cités, avec,le cas échéant, l'indicationdes passages pertinents	no. des revendications visées
A	SCHENKEL C J ET AL: "ELECTRICAL RESISTIVITY MEASUREMENT THROUGH METAL CASING" GEOPHYSICS, SOCIETY OF EXPLORATION GEOPHYSICISTS. TULSA, US, vol. 59, no. 7, 1 juillet 1994 (1994-07-01), pages 1072-1082, XP000526742 ISSN: 0016-8033 ———	

RAPPORT DE RECHERCHE INTERNATIONALE

Renseignements relatifs au   bres de familles de brevets

Document brevet cité au rapport de recherche		Date de publication	Membre(s) de la famille de brevet(s)		Date de publication
US 2001026156	A1	04-10-2001	FR	2807167 A1	05-10-2001
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US 4820989	A	11-04-1989	AT	91798 T	15-08-1993
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